

Audit



Report

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BRILLIANT PEBBLES PROGRAM

Report No. 94-084

April 14, 1994

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Acronyms

BMDO	Ballistic Missile Defense Organization
GAO	General Accounting Office
GPALS	Global Protection Against Limited Strikes
OSD	Office of the Secretary of Defense
SDIO	Strategic Defense Initiative Organization



**INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
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Report No. 94-084

April 14, 1994

**MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION
AND TECHNOLOGY
ASSISTANT SECRETARY OF THE AIR FORCE
(FINANCIAL MANAGEMENT AND COMPTROLLER)
DIRECTOR, BALLISTIC MISSILE DEFENSE
ORGANIZATION**

SUBJECT: Brilliant Pebbles Program (Project No. 3AS-0077)

Introduction

We are providing this final memorandum report for your information and use. The Strategic Defense Initiative Organization (SDIO)¹ began the Brilliant Pebbles acquisition strategy in June 1990. Because of continuing congressional development and funding constraints, the SDIO restructured the Brilliant Pebbles Program from a pre-engineering and manufacturing development program to a technology demonstration program in January 1993. With this change, the SDIO redesignated the Brilliant Pebbles Program as the Advanced Interceptor Technology Program (hereafter referred to as the Program) and transferred management responsibility to the Air Force in June 1993. Research, development, and test and evaluation costs for Brilliant Pebbles totaled nearly \$1.1 billion from October 1989 through November 1993.

Audit Results

We concluded that the SDIO and the Air Force had effectively managed the Brilliant Pebbles Program from May 1991, the time the program entered the pre-engineering and manufacturing development phase of the acquisition process, until December 1993 when the BMDO issued stop-work orders. The stop-work orders to Martin Marietta Corporation and TRW Incorporated (TRW), the two competing development contractors, initiated program termination action on the Program. The termination decision was not a reflection on the quality of program management.

In May 1991, Martin Marietta and TRW were awarded cost-plus-award-fee contracts totaling \$318 million and \$340 million, respectively, for the Program's pre-engineering and manufacturing development phase. Through December 3, 1993, Martin Marietta incurred contract costs of \$223 million and earned award fees of \$12.6 million and TRW incurred contract costs of \$221 million and earned award fees of \$9.6 million for meeting or exceeding its contract performance goals. Martin Marietta and TRW had completed

¹The SDIO was renamed the Ballistic Missile Defense Organization (BMDO) in May 1993.

development work specified in their contracts as modified except for flight tests, hardware and software technology demonstration tests, and systems integration tests that were scheduled for FYs 1994 and 1995. We were informed that those tests will not be performed, based on BMDO's decision to terminate further Program development.

Missile Defense interceptor technology advances made by Martin Marietta and TRW during the Brilliant Pebbles development effort may have applications on other DoD missile systems. Specifically, the Brilliant Pebbles' infrared seeker, miniature propulsion system, and guidance systems may provide technology improvements for other missile programs, including the Army's Lightweight Exo-atmospheric Projectile program. The Brilliant Pebbles' high-capacity space-based computers, solar panels, and laser communications technology may also be applied to future lightweight satellites.

Objectives

The audit objective was to evaluate the Brilliant Pebbles Program's management to determine whether the Program was being efficiently and cost-effectively developed. We followed our critical program management elements approach for the audit. The objectives and scope of the audit were tailored to the Program's status as a technology demonstration program. We reviewed program requirements; reliability, availability, and maintainability predictions; system integration planning efforts; definition of system interface requirements; test planning and preparation; schedule realism; cost estimating and analysis; contracting; engineering and logistics planning; and internal controls related to these objectives.

At the completion of the audit survey, we deemed that no additional audit work was necessary based on the results of audit and BMDO's decision to terminate the Program. Enclosure 1 discusses the detailed results of our audit.

Scope of Audit

This program results audit was performed from October 1993 through February 1994 in accordance with auditing standards issued by the Comptroller General of the United States, as implemented by the Inspector General, DoD, and accordingly included such tests of internal controls as deemed necessary. We reviewed data from the Program's inception in June 1990 through December 1993 to accomplish our audit objectives. Data reviewed included program acquisition documentation, system requirements documentation, system integration planning efforts, system interface requirements documentation, test plans and schedules, budget and cost estimates, manufacturing and logistics support preparation, and contracts. We also interviewed DoD, Air Force, Defense Contract Management Command, Defense Contract Audit Agency, and contractor officials involved in the Program. Computer-based data are not used in the report. Enclosure 4 lists the organizations visited or contacted.

Internal Controls

We assessed internal controls related to the critical program management elements of the Brilliant Pebbles Program and the most current vulnerability risk assessments made as part of SDIO's Internal Management Control Program. No material internal control weaknesses were found. The portion of the Internal Management Control Program we reviewed was implemented effectively.

Prior Audits and Other Reviews

Since March 1991, the Brilliant Pebbles Program has been the subject of three General Accounting Office reports that were directly related to our audit objectives. Enclosure 2 discusses the three prior audit reports.

Background

In 1983, the President directed the establishment of the Strategic Defense Initiative to eliminate the threat of first strike strategic nuclear ballistic missiles. The Secretary of Defense established the SDIO to manage the Strategic Defense Initiative. Space-based interceptors became a vital part of the SDIO missile Defense architecture because space-based interceptors could meet the requirement to intercept missiles during the boost and post-boost phases of intercontinental ballistic missile flight. In 1990, Brilliant Pebbles was chosen to fulfill SDIO's space-based interceptor requirement.

The Brilliant Pebbles concept consists of a distributed constellation of miniaturized interceptors orbiting the earth with the capability to detect, track, and destroy theater or strategic missiles by smashing into them at high speed during boost and post-boost flight. Each interceptor is housed in a lifejacket that provides, among other things, communications and on-orbit protection. In addition to the interceptor, the Program includes ground control and launch components. Enclosure 3 describes the interceptor ground and launch control components.

In 1991, the President restructured the spaced-based segment of the SDIO missile Defense architecture into the Global Protection Against Limited Strikes (GPALS) system. The restructure was mandated because the threat of a massive Soviet missile attack had become a remote possibility and defending against a smaller missile strike from a third-world nation or an accidental or terrorist launch had become the focus of ballistic missile defense. Implementation of GPALS resulted in Brilliant Pebbles' interceptor requirements being reduced from about 4,000 to about 1,000 space-based interceptors.

In the DoD Authorization Acts of 1991 and 1993, Congress limited the development and funding of space-based systems such as Brilliant Pebbles. In January 1993, the Under Secretary of Defense for Acquisition² approved SDIO's plan to restructure the Brilliant Pebbles Program as an Advanced Interceptor Technology Program based on the congressional direction. The Advanced Interceptor Technology Program was to include demonstrating key space-based interceptor and satellite technology requirements and performing risk-reduction tests.

Discussion

The SDIO and the Air Force managed the Brilliant Pebbles Program efficiently and cost-effectively within the development and funding constraints imposed by Congress. The May 1991 contracts called for the contractors to complete the pre-engineering and manufacturing contracts by July 1995. On contract completion, the SDIO planned to select one of the two competing contractors' Brilliant Pebbles prototypes for further development during the engineering and manufacturing development phase of the acquisition process. Since 1991, congressional legislation and a reduced Soviet threat have caused the President to restructure SDIO's missile Defense architecture. This restructuring resulted in the Program's acquisition strategy and contracts being modified materially. Between May 1991 and December 1993, the contracts with Martin Marietta and TRW were modified to implement GPALS and to implement Brilliant Pebbles contract replans I and II.

In August 1991, SDIO modified the contracts because the President restructured the space-based segment of the SDIO missile Defense architecture to the GPALS system. Martin Marietta and TRW contract costs were increased to \$363 million (an increase of \$45 million) and \$379 million (an increase of \$39 million), respectively, to fund the performance of GPALS implementation studies. The contracts were modified again in December 1991 to implement contract replan I. Contract replan I extended the completion of work on the contracts from July 1995 to January 1997. Martin Marietta and TRW contract costs were increased to \$483 million (an increase of \$120 million) and \$444 million (an increase of \$65 million), respectively, to cover costs related to inflation and extending the contract performance periods.

Restructuring the Brilliant Pebbles Program from a pre-engineering and manufacturing development effort to an interceptor technology demonstration led SDIO to implement contract replan II in January 1993. The contract replan II modifications:

- o restructured the scope of work from a pre-engineering and manufacturing effort to an advanced interceptor technology demonstration;

²Retitled Under Secretary of Defense for Acquisition and Technology in November 1993.

o extended the period of performance from January 1997 to January 2000;

o deleted three of the four planned hardware and concept validation tests; and

o replaced requirements for contract program acquisition reviews, such as critical design reviews, with semi-annual program technical reviews.

SDIO increased Martin Marietta and TRW contract costs to \$594 million (an increase of \$111 million) and \$617 million (an increase of \$163 million), respectively, to cover costs related to rescoping the contract statements of work and extending the contract performance periods.

Through November 1993, Martin Marietta and TRW completed development work specified in the contracts as modified. Further work on the contracts ceased when BMDO issued stop-work orders in December 1993, except for Martin Marietta's closeout tasks and subcontractor hardware to be completed in calendar year 1994. The BMDO decision resulted primarily from Congress reducing DoD's requested budget authority for the Program from \$640 million to \$35 million in FY 1994.

Management Comments

We provided a draft of this report to the addressees on March 15, 1994. Because we made no recommendations, no official comments were required and none were received. This report does not claim monetary benefits.

The courtesies extended to the audit staff are appreciated. If you have questions on this memorandum, please contact Mr. John E. Meling at (703) 614-3994 (DSN 224-3994) or Mr. Michael Claypool at (703) 614-1415 (DSN 224-1415). The audit team members are listed inside the back cover. Enclosure 5 lists the distribution of this report.



Robert J. Lieberman
Assistant Inspector General
for Auditing

Enclosures

Audit Results for Each Program Management Element Reviewed

The detailed audit results for each program management element we reviewed on the Brilliant Pebbles Program follows.

Program Requirements. Before January 1993, SDIO had adequately defined and validated Brilliant Pebbles' operational and mission requirements in the Program's operational requirements document. When the Brilliant Pebbles Program reverted to a technology demonstration program in January 1993, the SDIO and the Air Force were no longer required by the DoD Directive 5000.1, "Defense Acquisition," to maintain an updated operational requirements document for the Brilliant Pebbles Program.

Reliability, Availability, and Maintainability Predictions. The SDIO and the Air Force Program Office had established adequate controls for collecting and validating reliability, availability, and maintainability data during Brilliant Pebbles' pre-engineering and manufacturing development phase of the acquisition process. When the focus of the Brilliant Pebbles Program reverted to an interceptor technology demonstration in January 1993, the Air Force was no longer required to maintain a reliability, availability, and maintainability data collection system.

System Integration Planning Efforts. The Brilliant Pebbles system was to be integrated with National Missile Defense and Theater Missile Defense weapon systems as part of SDIO's missile Defense architecture. Brilliant Pebbles Program integration requirements were defined in the GPALS operational requirements document of February 1993. Through November 1993, the prime contractors had completed some subsystem integration tests, but had not progressed far enough to make an overall assessment of Brilliant Pebbles' integration capabilities.

Definition of System Interface Requirements. Brilliant Pebbles ground, launch, and space interface requirements were defined in the "Brilliant Pebbles Element Requirements Document," January 1993. Lawrence Livermore National Laboratory conducted ground, launch, and space components tests to demonstrate the Brilliant Pebbles concept and to define system interface requirements before the pre-engineering and manufacturing development phase of the acquisition process. The reversion of the Brilliant Pebbles Program to an interceptor technology demonstration eliminated the requirement to refine system interface requirements further except at the subsystem level.

Audit Results for Each Program Management Element Reviewed

Test Planning and Preparation. SDIO and the Air Force Program Office had established adequate test planning and oversight controls during the Program's pre-engineering and manufacturing development phase of the acquisition process. A draft Test and Evaluation and Master Plan was being coordinated when the Program reverted to an interceptor technology demonstration program in January 1993. Through November 1993, the prime contractors had met planned test events in the draft Test and Evaluation Master Plan. Test events to prove out the contractors' Brilliant Pebbles prototypes, such as flight tests, hardware and software technology demonstration tests, and systems integration tests, were scheduled for performance in FYs 1994 and 1995.

Schedule Realism. Martin Marietta and TRW's cost performance reports showed that their Brilliant Pebbles development efforts were largely on schedule through implementation of contract replan II in January 1993. Contract replan II shifted work scheduled for FYs 1993 through 1998 to FYs 1995 through 2000. As part of contract replan II, contractor performance of initial space flight tests was delayed for 6 months. Martin Marietta's tests were delayed because of Army delays in readying the Army's Ground Ballistic Interceptor discriminator hardware for the test. TRW's tests were delayed because the Air Force Space Command grounded the Aries II launch vehicles in August 1993 as a result of M56-A1 booster rocket motor failures.

Cost Estimating and Analysis. SDIO included the Brilliant Pebbles Program in the GPALS Global Missile Defense's life-cycle-cost estimates dated August 12, 1992, and cost and operational effectiveness analysis dated January 1993. Contractor fund status reports showed positive variances for Brilliant Pebbles work performed during 1993. We also concluded that SDIO, the Air Force Program Office, the Defense Plant Representative Offices, and the Defense Contract Audit Agency contractor resident offices were exercising adequate oversight over contractor costs incurred.

Contracting. Through November 1993, the prime contractors had completed all major work associated with the deliverables specified in the Brilliant Pebbles' pre-engineering and manufacturing development contracts as modified. Brilliant Pebbles' flight tests, hardware and software technology demonstration tests, and systems integration tests were not scheduled for performance until FYs 1994 and 1995. Implementation of contract replan II resulted in SDIO revising the contractors' contract data requirements lists. SDIO completed negotiations for the contract revisions during October 1993, but had not contractually implemented the revisions as of December 1, 1993, when the contract stop-work orders were issued.

Engineering and Logistics Planning. Martin Marietta and TRW were adhering to System Engineering Master Plans established for developing their Brilliant Pebbles prototypes. We also concluded that the Air Force Program Office was providing effective oversight of contractor system engineering and logistics planning for contractor activities associated with scheduled space flight tests and subassemblies development.

Prior Audits and Other Reviews

On September 8, 1992, the General Accounting Office (GAO) issued Report No. GAO/NSIAD 92-282 (Office of the Secretary of Defense [OSD] Case No. 9142), "Strategic Defense Initiative: Some Claims Overstated for Early Flight Tests of Interceptors." GAO reported that the SDIO overstated the claims of success for one of two Brilliant Pebbles flight tests. GAO found that SDIO did not disclose that it had reduced the technical performance goals of the flight tests yet continued to refer to the original goals in the Brilliant Pebbles Test Plan. SDIO reported that the flight test was 90 percent successful using the reduced performance goals. GAO stated that the 90 percent success claim was significantly overstated when flight test results were measured against the original goals. The report did not contain recommendations.

In February 1992, the GAO issued Report No. GAO/IMTEC 92-18 (OSD Case No. 8889), "Strategic Defense Initiative: Changing Design and Technological Uncertainties Create Significant Risk." GAO reported that SDIO included space-based interceptors (Brilliant Pebbles) in the missile Defense system architecture even though the Missile Defense Act of 1991 did not address whether space-based interceptors should be in the architecture. In addition, GAO reported that significant technological and integration challenges must be overcome to design, develop, and deploy a space-based system. GAO recommended that the Secretary of Defense provide Congress with an analysis of the design and cost implications to the missile Defense system architecture of including space-based interceptors but never deploying them and excluding the space-based capabilities now and adding the capability later. GAO also recommended that the Secretary of Defense develop an implementation plan for missile defenses. The Secretary of Defense agreed with the recommendations, stating that an analysis of the missile Defense system architecture and its implementation plan would be provided to Congress as part of the President's FY 1993 budget submission.

In March 1991, the GAO issued Report No. GAO/NSIAD 91-154 (OSD Case No. 8539A), "Strategic Defense Initiative: Need to Examine Concurrency in Development of Brilliant Pebbles." The report suggested that the Congress consider whether the concurrency in the Brilliant Pebbles Program was justified by the President's need to make a decision by the summer of 1993 on whether to begin full-scale development and deployment. If not, GAO recommended that Congress direct DoD not to fund pre-full-scale development until Lawrence Livermore National Laboratory's flight test program had adequately demonstrated the feasibility of the Brilliant Pebbles concept. Subsequent to the report, SDIO revised the Brilliant Pebbles acquisition strategy to reduce schedule concurrency significantly.

Brilliant Pebbles' Ground Control and Launch Components

In addition to space-based interceptors, the Brilliant Pebbles Program consists of ground control and launch components.

Ground Control Component. The ground component includes control and operation facilities, a training support facility, and a maintenance facility. Operationally, the control and operation facilities will allow the operational user to communicate with and control each space-based interceptor.

Launch Component. The launch component provides the means to launch the space-based interceptors into operational orbit. The launch component consists of all hardware, software, facilities, and personnel needed to deploy the space-based interceptor. Major hardware items include the launch vehicle (Aries II, Titan III, or Atlas II), the interceptor dispenser, and the ground and airborne support equipment.

Organizations Visited or Contacted

Office of the Secretary of Defense

Office of the Under Secretary of Defense for Acquisition and Technology, Washington, DC

Office of the Deputy Under Secretary of Defense for Advanced Technology, Washington, DC

Ballistic Missile Defense Organization, Washington, DC

Department of the Air Force

Office of the Secretary of the Air Force, Washington, DC

Commander, Space and Missile Systems Center, Air Force Materiel Command, Redondo Beach, CA

Advanced Interceptor Technology Program Office, Redondo Beach, CA

Other DoD Organizations

Defense Logistics Agency, Alexandria, VA

Defense Contract Audit Agency, Alexandria, VA

Defense Plant Representative Office, Martin Marietta Corporation, Denver, CO

Defense Plant Representative Office, TRW Incorporated, Redondo Beach, CA

Defense Contract Audit Agency, Martin Marietta Corporation Resident Office, Denver CO

Defense Contract Audit Agency, TRW Incorporated Resident Office, Redondo Beach, CA

Defense Contractors

Martin Marietta Corporation, Defense Space and Communications, Denver, CO

TRW Incorporated, Space and Defense Sector, Space and Technology Group, Redondo Beach, CA

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